Control of microgrids in island-mode with converter-interfaced generators

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I. INTRODUCTION

The electrical system is traditionally fed by large centralized power plants connected to the power transmission network. Recently, because of environmental considerations, technological developments and tax incentives for renewables, the grid architecture is changing from centralized to decentralized energy supply with distributed generators (DGs) connected to the utility grid. The DG technology may include microturbines, fuel cells, wind, photovoltaics (PV), internal combustion engines, etc. Because of the small size of the emerging DG, the generators can be positioned near the consumers, which reduces the amount of energy lost in the power transfer across the transmission lines. DG can also lead to improved reactive power support and voltage profile, removal of transmission bottlenecks, usage of environmental friendly resources (by private-owned, low-voltage connected on-site generation) and postponement of investments in new transmission systems and large-scale generators.

As DGs are increasingly being connected to the utility grid, their task is changing from back-up elements to primary energy resources.

One of the advantages of distributed generation, the increase of reliability of the electrical energy supply, can be realized by the introduction of the microgrid concept. A microgrid is a cluster of supply, storage and load elements connected to the low-voltage distribution system and it can disconnect to stand-alone operation in case of emergency [1]. With the emerging microgrids, new control methods for the microgrid-elements are required, which is the focus of this research.

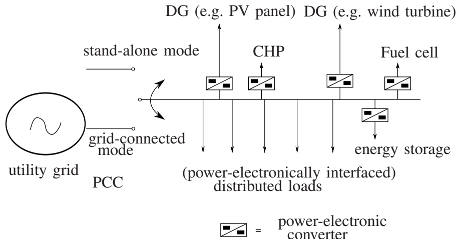

Figure 1. Microgrid with (power-electronically interfaced) loads, storage and DG

II. MICROGRID

The development of the distributed generation (DG) technology, the increased public interest in renewables and the reduced costs are stimulating the investments in DGs. New opportunities for the coordinated operation of DGs rise with the introduction of the microgrid [2]. Microgrids can facilitate the penetration of renewables and other forms of DG into the utility grid and help in power quality issues and service reliability. The microgrid elements are mostly connected to the microgrid via power-electronic interfaces. The microgrid can run in two operating conditions: stand-alone mode and grid-connected mode.

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III. Microgrid control

Microgrids have different characteristics in comparison with conventional electrical systems and, therefore, different operation and control methods are required [3].

In literature, several control schemes for islanded microgrids are proposed.

In the concentrated control method, an independent control unit sends control signals to the inverters. An example of concentrated control is the master-slave scheme, where the microgrid consists of one master inverter and all other are slave units. The main problem of these control principles is that a high-bandwidth communication link between the units is needed, which poses limits on the position of the units and noise problems, it also reduces the reliability of the microgrid as the grid control depends on the communication link.

Communication and/or extra wires can be avoided by implementing active power/ frequency-droop control, similar to droop control in conventional grids. In this control strategy, the inverters themselves determine their set-points for instantaneous active and reactive power based on local measurements of voltage and frequency only.

In this research, a new control strategy for islanded microgrids is presented where it is taken into account that the characteristics of the microgrid differ significantly from those of conventional high-voltage transmission grids. Firstly, in conventional grids, the frequency control is based on the rotating inertia in the system, whereas islanded microgrids lack significant inertia because most elements are power-electronically interfaced. Secondly, low-voltage distribution grids have mainly resistive characteristics, unlike the mainly inductive transmission grids. These differences between conventional grids and microgrids require the development of new control methods specifically designed for microgrids. Furthermore, as renewable energy resources are increasingly being connected to the (micro-)grid, an important part of the sources in the microgrid are not (fully) dispatchable, e.g. the power output of these sources is optimized by means of maximum power point tracking.

In this research, the aforementioned restrictions for microgrid control are taken into account. The new control scheme consists of several nested loops. The inner loop controls the grid voltage, and thereto in this research, several control schemes (PI controller, fuzzy logic, etc.) are compared [4]. The grid voltage setvalue is determined by the outer power control loop. For the active power, a new control scheme, the V_g/V_{dc} control is being developed. Reactive power control is secondary, but is needed e.g. to avoid circulating currents between different inverters.

IV. Conclusions

In this research, microgrid control is developed avoiding high-bandwidth communication and based on local measurements only, while taking into account the specific characteristics of the microgrid.

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